870 Ma age of South Delhi Orogeny: A study on Geochronology of the granites and the meta-sediments, NW India.

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#shareEGU2020, EGU General Assembly 2020
Outline of the presentation

❖ Introduction and geology of study area

❖ Objectives

❖ Methodology

❖ Deformation in the study area
  ➢ Three phase folding
  ➢ Shear zones
  ➢ Ductile shearing

❖ Results
  ➢ Zircon dating
  ➢ Monazite dating

❖ Discussion
Introduction

Part of lithological map of Aravalli range (S. Singh et al., 2020, Springer Nature Switzerland AG 2020).

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Objective

❖ To establish chronological order of different granitic intrusions and their relationship with the tectonic history of the area.
We have mapped the area on an enlarged scale (1:10,000) in parts of Survey of India toposheets, 45J/3,4,7,8 between Roopnagar and Babra.

Different litho-units were mapped and structural data related to different generations of folding were collected.

We distinguished different generations of folding based on overprinting relationship of strain fabric and interference pattern.

Four shear zones (SZ-I-IV from west to east) were mapped and oriented samples were collected.

Shear sense study (on XZ section, parallel to stretching lineation and perpendicular to foliation).
❖ Concordia age is calculated with $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$ ratio by using U-Pb data (SHRIMP method) of G1, G2, G3 and G4 granites.

❖ Monazite dating of the garnet-staurolite-quartz-feldspar-biotite schist and granitic pebble from the basal conglomerate zone.
Detailed structural map of the study area (S. Singh et al., 2020, Springer Nature Switzerland AG 2020).
Model of three phases of deformation in study area

Undeformed

F1

F2

F3
Field photographs of F1 Folds (Recumbent/Reclined)
Field photographs of F2 Folds
Field photograph of type 3 interference pattern
Field photograph of F3 Fold
F2 Ductile shearing in mica schist
CL Images of Zircon

Earth Sciences
Results

TKB-2(G1)

- The data plot in a well-define cluster on Concordia (Figure), with the exception of TK2.15 and TK2-17, which record the highest $f_{206}$ values and plot off Concordia.

- The concordant population of 27 zircon define a Concordia age of 982±3 Ma, which is the best approximation of the emplacement age of the granite protolith in sample TKB-2.
**TKB-3(G2)**

- Two zircon grains record older $^{207}\text{Pb}/^{206}\text{Pb}$ ages, with the one near-concordant point (TKB3.7) giving an age of $2765\pm18$ Ma. These are considered to record some xenocrystic components in the granite protolith (Figure).

- The remaining points plot cluster with a Concordia age of $992\pm12$ Ma.
One analysis yielded an older age of ca 3.0 Ga, but plots slightly under Concordia. This grain is interpreted to reflect a xenocrystic component in the granite dyke.

The oldest cluster of concordant grains in the population provide a Concordia age of 946±18 Ma, which could reflect the emplacement age of the granite dyke.

One zircon (TKB4-7), analysed twice during the session, provides a concordant data point at 270±12 Ma. This young grain would put the age of emplacement of the granite dykes at 270 Ma, with the older populations.
TKB-1(G4)

❖ The data plot in a well-defined cluster on Concordia, with two analyses within that population plotting with larger errors and off Concordia, corresponding to the two analysis with the highest $f_{206}$ (TKB1-25 and TKB1-26).

❖ The concordant points correspond to a Concordia age of $878\pm9$ Ma, which we take to be the best estimate for the emplacement age of the granitoid.

❖ One analysis, TKB1-14, plots well-away from the Concordia age, with a $^{207}\text{Pb}/^{206}\text{Pb}$ age of $1634\pm22$ Ma.
Monazite Dating

- EPMA Th-U-total Pb monazite geochronology of the garnet-staurolite-quartz-feldspar-biotite schist from the basal conglomerate zone shows three distinct ages, ca. 1600Ma, 850 Ma and 700 Ma.
BSE images and X-ray mapping images of monazite grains of Bar meta-conglomerate samples.
Relative probability plots (using Isoplot add-in for Excel, 64)
Discussion

❖ Three stages of deformation ($D_{1-3}$).

❖ Four types of granite plutons ($G_{1-4}$).

❖ The $D_1$ deformation produced $F_1$, reclined/recumbent folds with $S_1$ axial planar fabric in greenschist facies metamorphic condition.

❖ The $D_2$ deformation produced NE-SW trending $F_2$ folds coaxial with $F_1$ (type 3 interference pattern), crenulations and $F_2$-axial parallel ductile shear zones.

❖ The $D_3$ deformation produced NW-SE $F_3$ folds, which superimposed on $F_1$ and $F_2$ to create type 1 and 2 interference pattern.

❖ U-Pb data (SHRIMP method) of $G_1$, $G_2$ and $G_4$ granites yield Concordia age calculated with $^{206}\text{Pb}/^{238}\text{U}$ and $^{207}\text{Pb}/^{235}\text{U}$ ratio at $\sim$982 Ma, $\sim$992 Ma and $\sim$878 Ma respectively.
Petrographic images of granites in study area

Rupnagar granite (G1)

Pratapgarh granite (G2)

Sumel granite (G3)

Bar-Birintia-Sewaria granite (G4)
Petrographic images of F2 Ductile shearing in mica schist
EPMA Th-U-total Pb monazite geochronology of the garnet-staurolite-quartz-feldspar-biotite schist from the basal conglomerate zone shows three distinct ages, ca. 1600 Ma, 850 Ma and 700 Ma.

Correlating with granite SHRIMP age, the ~ 864 Ma corresponds to Delhi metamorphism and D1 deformation (~ 870 Ma).

We interprete that the $G_4$ granite is sytectonic and $G_{1-3}$ were pre-tectonic to $D_1$ deformation.

Thus the South Delhi orogeny is constrained by the age of $G_4$ granite at ~ 878 Ma (~ 870 Ma).

The $G_{1-3}$ granites are pre- Delhi orogeny and probably constrain the age of rifting of the Delhi basin.
The event ca. 1600 Ga probably belongs to pre-Delhi age, which is observed in nearby pre-Delhi localities like Sandmata terrane.

The $G_{1-3}$ granites are pre-Delhi orogeny and probably constrain the age of rifting of the Delhi basin.
Thank You!